that the earth was covered with oaks, magnolias, willows, &c. before the Tertiary began. Gradually we are gathering the details of this wonderful history, and ultimately we shall be able to report the *facts* with a good degree of fulness; but the causes which inspired the revolutions that have taken place in plant life, and the processes by which these great changes have been effected, seem to be as inscrutable as ever.

XXIV.—*On the Structure and Affinities of the Genus* Tristychius, *Agass.* By Thomas Stock, Natural-History Department, Museum of Science and Art, Edinburgh *.

[Plate VII.]

Tristychius fimbriatus, Stock. (Pl. VII. figs. 1 and 1 *a*.)

This spine I owe to the kindness of those promising young naturalists Messrs. Kinnear and Anderson, who discovered it in the Carboniferous Limestone series at Gilmerton, near Edinburgh. It appears to be hitherto undescribed.

Description.—It is distinctly sigmoidal in shape; but the curvature presents an exaggerated appearance through fracture. The restoration (Pl. VII. fig. 1 *a*) gives a more correct idea of its original shape. The direction of the curve in the distal region is peculiar, and, indeed, almost without a parallel in Selachian acanthoid remains. Nevertheless I attach very slight importance to it as a systematic character. It is possibly due to disease, of which there is some evidence in certain pustular appearances seen near the pointed extremity of the spine (Pl. VII. fig. 1). It is $1\frac{2}{3}$ inch in length, and $1\frac{1}{2}$ line in greatest width. Its surface is smooth; but a shallow and wide groove occupies a nearly central position along the middle third of the spine. It is difficult to say how far such grooves, which occur rather frequently in the spines of various genera and species, are normal, or whether they arise from the falling-in of the walls of the spine as the soft internal part decays. In the case of *Pleuracanthus*, in which this middle groove is often visible, the appearance is due to decay in all the cases that have come under my notice. But in the example under consideration I am inclined to think that the appearance is normal, as the walls are apparently thick and the

* Communicated by the Author, having been read to the Edinburgh Geological Society, March 15, 1883.

pulp-cavity small; its value as a specific character must, however, be accepted with considerable reserve.

The seven denticles are confined to the distal fourth of the spine, and form a rather crowded series; they slightly increase in length proximally; and their bases are *fused* into the walls of the spine. The second row (if existent) is concealed in the matrix. The inserted portion of the spine is not preserved.

Affinities.—Giebel * figures a spine which may possibly come near the one just described. In the text he refers it to *Styracodus acutus*, a species and genus founded by himself for the reception of a very *Ctenoptychius*-like fossil (a resemblance he was quite aware of himself). In the plate, however, it appears as *Hybodus*, along with other forms referred to the same genus. The reference, however, is clearly due to carelessness in naming the figures; for it is evident from the text that Giebel had no conception that the spine could possibly be related to the remains that he figures on the same plate as belonging to *Hybodus*. Nevertheless there is some ground for believing (unless all faith is refused to his figures) that the spine which he referred to *Hybodus* is nothing but *Pleuracanthus* †, and therefore unconnected with the remains in question, but that the spine named *Styracodus acutus* may really belong to them. This spine is unfortunately broken off just at the point where the denticles would commence if it be, as I surmise, a species of *Tristychius*; but in other respects it conforms closely enough to the genus. From his figures 5 and 7 it is evident that some tolerably undisturbed Selachian fragments had been discovered; for we see a number of teeth associated with cuticular appendages upon the same slab. Separate figures of the teeth are given ‡, from which it is quite possible to gather that they bear a similarity (as I shall show hereafter) to teeth that occur not unfrequently in our own Lower Carboniferous or Calciferous Sandstone series, and which are associated with undoubted *Tristychius* spines. Whilst this generic affinity may be asserted pretty confidently, there is much doubt as to whether the species from the two localities are the same; and therefore

* In Germar's 'Versteinerungen des Steinkohlengebirges von Wettin und Löbejün,' p. 71, tab. xxix. fig. 4*b*, and reproduced in Pl. VII. figs. 2 and 2*a*.

† *Loc. cit.* fig. 8; reproduced in Pl. VII. figs. 3 and 3*a*. May not his *Chilodus gracilis* be a *Diplodus* tooth? *loc. cit.* fig. 2, reproduced Plate VII. figs. 4 and 4*a*. One-pronged *Diplodus*-teeth are occasionally met with, whether due to fracture or not it is not easy to say.

‡ *Loc. cit.* fig. 5, *a*, *b*, and figs. 6 and 6*a*; reproduced, Pl. VII. figs. 5, 5*a*, & 6, 6*a*.

Tristychius fimbriatus, Stock, may be looked upon as distinct from, though probably related at no great distance to, *Styracodus acutus*, Giebel.

Tristychius arcuatus, Ag.

This spine is rather common in the vicinity of Edinburgh. I have possessed or seen in other collections nearly a hundred examples. It appears to be commonest on the Burgh Lee horizon (Edge Coal), probably from the fact that the beds there have been pretty carefully examined; but it also extends down to some of the lowest beds of the Calciferous-Sandstone series of the district. I am acquainted with it from Abden, near Kinghorn, Fife (Edge Coal?), South Queensferry (Burdiehouse), Grange Quarry, Burntisland, Fife (Burdiehouse); Juniper Green (Wardie, collected by Mr. Henderson, and presented by him to the Museum of Science and Art); Hailes Quarry (Wardie); and from Carolina Park (Granton). A consideration of this ample material has elicited a few facts worthy of being put on record.

I have figured (Pl. VII. figs. 7 & 7*a*) the specimen collected by Mr. Henderson, and now in our collection, partly as being a good typical example of the larger form of the species, and also to show that the denticles near the point merge into a ridge with a ragged (scarcely denticulated) edge. The general shape has been preserved; but the proximal half has been much injured. On the side, at the point, there is a very small smooth area; and immediately below it the ridges and furrows are pretty strongly marked. Three distinct but not very prominent parallel ridges extend back from the anterior margin for a short distance; and the rest of the area is in this specimen finely and interruptedly striated. There is, however, a great range of variation in various specimens as to the strength of the sulcation and ridging. Some are nearly smooth, and those the largest; others, usually smaller specimens, are often strongly ridged and sulcated. These differences are so apparent in different examples that for a long time I thought a stable specific distinction might be made out between them; but wider experience has convinced me that a clear gradation can be easily traced between them.

Having now discussed the fragmentary evidence upon which the genus *Tristychius* has been hitherto chiefly known, we are able profitably to advance to the consideration of certain specimens in which that evidence is combined with other facts of a much higher order of importance. Amongst these the first to call for notice is a considerable fragment of the

vertebral column found in connexion with the remains of two spines (Pl. VII. fig. 8), the whole undoubtedly belonging to the same fish. This fragment has been preserved on a thin piece of weathered ironstone shale, and was picked up by myself at Carolina Park, near Edinburgh *.

Description.—There are the remains of two spines; the shape of the larger is well seen, chiefly as an impression, however, on the slab. It is 2½ inches in length, a fairly large specimen. The cast shows that it was distantly and regularly striated. I can detect traces of one or two denticular impressions only. It conforms to typical examples of the species. This I interpret as the *right pectoral spine*. Slightly posterior in position and directed towards the opposite side of the axis are the much-broken remains of the base of a second spine (Pl. VII. fig. 8, *s*). This is proved conclusively by the pulp-cavity, which is seen in section at the edge of the slab. I interpret this as the remains of the *left pectoral*. They were probably paired spines at any rate; and their position with regard to the axial column is in favour of their being pectoral. There is much difficulty, however, in disentangling the confused appearances presented on that part of the slab immediately behind the spines; and at the anterior inferior angle of the slab some plant-remains † complicate matters, so that another reading could I dare say be defended. The position of the bases of the spines (almost overlapping) with regard to each other shows that there has been some disturbance during fossilization; and the disturbance which has pushed in the spine *s* (Pl. VII. fig. 8) has also pushed outwards the two neural spines *n* (Pl. VII. fig. 8), which occupy a peculiar and rather misleading position with regard to the spine *s'*. On the lower front angle of the slab there are some appearances dubiously referable to the pectoral fin (Pl. VII. fig. 8, *r*)

The remains of the axial column (2½ inches long) are in a tolerably good state of preservation. The apophysial elements are represented by a double series of closely approximated spines (neural and hæmal), consisting of granular cartilage, numbering between twenty and thirty in each row. They are rather better preserved on the neural than on the

* I have found this locality, situated at the extreme western end of the Wardie and Granton sandstones and shales, extremely prolific in fish fossils. Unfortunately they are not usually in good preservation. It is noticeable that nearly all of the specimens collected are referable to forms already and commonly known from the eastern and more frequently worked shales.

† Left out in the drawing.

hæmal aspect *. The spines of the neural row where best preserved are about 4 lines in height, triangular, and acutely pointed, the points being directed backwards. The hæmal spines (not well preserved) appear to alternate with the neural, are apparently of the same size and shape, and are directed forwards. Some allowance must be made, however, in this description, for *post mortem* disturbance and alteration.

The axis evidently consisted of *a persistent notochord.*

In this (so far as I am aware) the earliest known shark in which readable traces of the axial skeleton have been preserved, it is important to observe that these conform in rather a significant way to those types of vertebral organization which are regarded as the most ancient and the simplest. The discovery of this single specimen, however, is not sufficient to justify any certain conclusions as to the presence or absence of a more highly organized skeleton in other sharks of the same age. Prof. Newberry has indeed drawn attention † to an interesting specimen found in the Carboniferous rocks of Ohio (Waverly group), which he considers to represent a grade of organization in some respects higher than in most of the sharks of the present day. His remarks are of great interest, and need no excuse for being quoted. He says :—" I should also mention in this connexion a remarkable shark's tail found at Vanesburg, Kentucky. . . . This specimen, which is nearly a foot and a half long, shows the outline of the heterocercal tail of a shark which must have been 8 or 10 feet in length. The vertebral column is seen to reach far into the upper lobe of the tail. The vertebræ have certainly disappeared, leaving a smooth band to mark the space they occupied. This is bordered on either side by the impression of linear pointed apophysial bones, which were evidently much better ossified than the centra of the vertebræ. The lower lobe of the tail is formed by a number of *strong ossified rays*! This shows that this Carboniferous shark. . . . . had a skeleton in some respects more fully ossified than most of the sharks of the present day." This brief notice, which he promised to supplement by a full description ‡, possibly may not represent his riper views as to the reading of the specimen; but it appears to me that, taking the description as it stands, there are several assumptions which are scarcely warranted by the facts; and chief of these is the implication that the axis was

* I consider the upper row as figured to be neural, though there is not much to show which is neural and which is hæmal.

† Geol. Surv. Ohio, vol. i. part 2 (Palæontology), p. 279.

‡ I am quite ignorant whether his promise has been fulfilled or not.

segmented, and, moreover, that the segmentation had proceeded so far as to be represented by distinct centra. So far as I am aware, there is no very convincing evidence at present available that any Carboniferous shark possessed centra. Numerous biconcave vertebræ have indeed been discovered, especially in the English coal-measures; but further observations are wanting before any of these can be referred with certainty to the skeleton of a Selachian fish.

The next specimen to be described is preserved in a nodule, and is valuable as affording information more particularly with regard to the exoskeleton of the fish. The nodule measured about $8\frac{1}{2} \times 7 \times 3$ inches before it was broken up for examination. I found it at Hailes Quarry, near Edinburgh, in the Calciferous-Sandstone series. The part protruding from the bank of shale had become a good deal weathered, and a considerable fragment must have at some time dropped off and become lost. The weathering has extended inwards for an inch or two, which is so far a fortunate circumstance, as a better view is got of the teeth than would have been possible otherwise. The rest of the nodule is hard and unweathered; and though I succeeded in developing the spines and several more teeth, something has no doubt escaped detection *.

Description.—The *teeth* are seen to be numerous; but it is impossible accurately to estimate their number, as they lie in much disorder, and many of them are very imperfectly seen. One of the largest (Pl. VII. fig. 9, nat. size) is $3\frac{1}{2}$ lines wide and $1\frac{1}{2}$ line high. The middle cusp is well developed, and is flanked by lateral cusps, three on each side (one of them is broken away in the example figured). These decrease in height, first suddenly as compared with the middle cusp, then more gradually with regard to each other. The cusps are strongly grooved. The grooves are flexed, and diminish in width as they converge towards the apex. The wide spaces that separate the cusps are also deeply grooved. This deep sulcation gives the tooth a strikingly ornamental and characteristic appearance. The inserted portion is short, and covered with equally spaced narrow ridges (Pl. VII. fig. 10). These ridges are apparently prolonged beyond the base into root-like attachments, and in some specimens they appear to bound cavities in the bases of the teeth. It is also worthy of note that the free portion of the tooth is very oblique to the base, a narrow groove marking the division between them. The other teeth differ from the one described chiefly in the varying depth of the sulcation and in the distances the cusps are set apart

* Shark nodules are particularly refractory under development.

from each other. In a few cases the base of one cusp rises from the base of its neighbour without any distinct space intervening. The middle cusp of one large tooth shows at its base small depressed elliptical areas enclosed by folds of the ridges.

It is rather singular that this elegant tooth should for so long have escaped detection; nevertheless, so far as I have been able to discover, it has not been previously described. It bears a general resemblance, however, to the teeth figured by Giebel * as *Hybodus carbonarius* and *Hybodus vicinalis*; and the evidence is in favour of their being allied.

A very pretty little tooth found by Mr. M'Leish in the Calciferous-Sandstone series near Bathgate, and given to me by Mr. Henderson for examination, shows (Pl. VII. fig. 11) some deviation from the teeth in the Hailes specimen. In it the middle cusp is nearly of the same width from the base to the apex, and the ridging and sulcation are rather more regular; but these are differences which may be expected to occur in different individuals of the same species and in different positions in the mouth.. I do not think it is specifically distinct.

I have figured (Pl. VII. fig. 12), from another specimen, a few teeth that lie almost undisturbed. The information derivable from the Hailes specimen is rather meagre as to those points connected with the buccal cavity upon which light might be expected to be thrown by the discovery of a tolerably good specimen. After a prolonged scrutiny of the material, I think the following statements may be considered as at any rate not widely removed from the truth. The greatest width of the aperture was from 2 to 3 inches, probably more. The mandibular and palatal cartilages were curved, the curves being broadly elliptical or circular. The teeth were set in numerous compact rows, one row behind another, in regular (not, I think, alternate) order, which (in a second specimen) are seen to occupy a space of about an inch, measured in the direction of the axis.

The Spines.—In this and the following specimens I have found the spines associated with the teeth in an identifiable condition. In this they number *four*; and though all are fragmentary, the shape and sculpture of the fragments are well preserved. There is not the slightest doubt that they perfectly resemble each other in size and contour, and that the ornamentation is identical in every respect. There is also no doubt that they are easily identifiable with *Tristychius arcuatus*,

* *Loc. cit.* Reproduced on Pl. VII. figs. 5, 5 *a*, & 6, 6 *a*.

Ag. This is a matter of evident importance; for upon the correctness of the reference depends a great part of the value of this communication. I have therefore given figures (Pl. VII. figs. 13 & 13 *a*) of the best-preserved fragment, and placed them beside the typical form (Pl. VII. fig. 7) for comparison.

The number of spines found with this specimen is quite conclusive to my mind as to the fact that some of them (perhaps all) belonged to the horizontal fins. If any were dorsal (prepinnate or not), they did not differ from the paired spines. Yet a real distinction has apparently been established by Messrs. Hancock and Atthey* between the paired and dorsal spines of *Gyracanthus*; and, from analogy, we should be prepared to expect that that distinction would hold good for other genera that possessed both.

There is no evidence of the presence of *sphenonchi*, the cephalic spines found associated with *Hybodus*.

Cuticular appendages.—There are a number of minute bodies scattered all over the stone, which are the remains of the dermal skeleton. They are so small, however, so much fractured, and simulate by their sculpture (where obscurely seen) the grooved cusps or bases of the teeth so closely, that it is exceedingly difficult to get a view of a specimen sufficiently isolated to be able to say with certainty what was its shape. In front of the largest fragmentary spine is a cluster of them, where they are rather better seen than elsewhere. They bear a pretty strong resemblance to clusters of caraway seeds. Sometimes two and sometimes three appear to be placed together, with distinct interspaces, however, and each traversed by one or two rather coarse striæ. The difficulties of observation, however, are so great that better material may correct this description. On holding the slab obliquely to the light and looking carefully with the lens, I think any one would, at any rate, be convinced of the existence of these tubercles, though opinions might differ as to their configuration. One that I thought I had isolated proved on more careful observation to be the base of a broken tooth, the striæ only distinctly appearing above the matrix! Sometimes I have thought that they approach the body figured by Giebel† as belonging to *Hybodus carbonarius*, and which there is good reason for believing was an appendage of the dermis. I have tried to figure a specimen, Pl. VII. figs. 15 & 15 *a*, which figures present my view of its shape; but I must leave to the future

* Northumb. & Durham Nat. Hist. Trans. vol. iii. p. 109.

† *Loc. cit.* (reproduced Pl. VII. figs. 14, 14 *a*). His figure is probably incorrect.

the corroboration or disproof of the accuracy of the representation. If my reading is correct, they bear a rather striking general resemblance to those found associated with the spines of *Ctenacanthus hybodoides*, Ag., for the knowledge of which association we are indebted to the painstaking researches of Messrs. Hancock and Atthey. I owe a large fragment of this spine to the kindness of my friend Mr. J. M. Campbell, of the Kelvin Grove Museum, Glasgow, who obtained it from the Coal-measures of his district. On splitting the shale on its posterior side I found, as I was led to expect I should probably find from my experience with *Gyracanthus**, several well-preserved tubercles, of one of which I give a figure (Pl. VII. fig. 16). It has never, so far as I remember, been figured before; and a comparison of it with the tubercle of *Tristychius arcuatus*, Ag., will at once show that there is a decided resemblance between the two. A strong resemblance exists also between them and the tubercle of *Gyracanthus* (Pl. VII. figs. 17 & 17 *a*); and these are all, or nearly all, of the Carboniferous sharks upon which dermal appendages have as yet been clearly proved† to exist. Nevertheless this resemblance may not necessarily imply close affinity.

Cranial Cartilage.—The cranial cartilage preserved in this specimen presents the usual mosaic appearance with which the student of fossil sharks is familiar. When freshly fractured, the black glossy appearance, due to the change to bitumen, is apt to deceive the unwary by an appearance simulating that of minute ganoid scales, such as are found on *Acanthodes*.

The next and last specimen to be described occurs in a nodule, found by myself at Trinity near Edinburgh, in the Calciferous-Sandstone series (Wardie horizon).

The nodule is not entire; it contains, however, the remains of the cranium, and is valuable as throwing light upon the dentition of this fish. The nodule measured $5 \times 4 \times 2$ in. (before it was broken up for examination) and was very pyritous and hard.

Description.—I succeeded in developing a fragment of one *spine*. It conforms in sculpture so closely to those last described that all might have belonged to the same fish. What can be seen of its shape agrees also; and the denticulation on the posterior area is identical. There can be no doubt that it belongs to the same species.

* The shale at the back of the spines should always be carefully examined for tubercles.

† Many very different dermal buckles or tubercles, however, have received special names, having been mistaken for teeth.

Cuticular Appendages.—Dimly seen; but there are traces of them, and these do not differ (so far as can be made out) from those described as belonging to the last specimen. They are most visible on the extreme posterior edges of the halves of the nodule.

Teeth.—On opening this nodule I thought I had settled the long-standing controversy as to the true nature of the bodies described by Agassiz as *Ctenoptychius pectinatus*, and believed by him to be teeth, but by Messrs. Hancock and Atthey* to be appendages of the dermis. A number of broad, low, sulcated teeth were seen lying in much disorder, yet compacted together, and forming evidently no inconsiderable portion of the armature of a Selachian mouth. An examination with the lens, however, resolved the majority of these teeth into forms with which I had been made very familiar by the material previously considered in this paper; and I must confess to a moment of keen disappointment as this fact became apparent. Nevertheless, after repeated examination of the specimens under every optical condition, and after a consideration of other evidence, I have gradually been led to adopt the view that *Ctenoptychius pectinatus* is a part of the dentition of *Tristychius arcuatus*,—that is to say, that the teeth described in the last specimen and well seen in this (teeth with elevated median cusps and well-developed lateral cusps, strongly grooved, and with short striated and rooted bases) are accompanied in the same mouth, but in a different part of it, by teeth with no specially raised median or lateral elevations (the fasciculations of these teeth may probably, however, be homologous with the cusps of the other kind), with a low, nearly straight area, with well-developed bases, fringed (in many specimens) by root-like attachments. The gradations between the two kinds (if we may hope that a clue has been given) is not so very surprising. Slightly elevate the grooved and (already) fasciculated denticles of *Ctenoptychius pectinatus*, first at the middle and then at the sides, and you have *Tristychius arcuatus* teeth. Depress (and in some teeth the elevation is slight) the cusps of the latter, and you have the former. It is a great pity that the evidence furnished by the specimen is no clearer; yet I consider it sufficient to warrant the expression of these views. In most of the teeth that are visible the distances between the cusps are much reduced when compared with some of those described in the preceding specimen. In one

* Northumb. & Durham Nat. Hist. Trans. vol. iii. p. 116. See also a note by myself in the Ann. & Mag. Nat. Hist., April 1882, p. 256. Messrs. Hancock and Atthey acknowledged their great resemblance to teeth.

tooth (Pl. VII. fig. 18) the middle cusp is much lower than in the others; and as it lies with its convex aspect uppermost, deeply grooved and prominently ridged, the lateral cusps on one side hardly at all differentiated from the rest of the free area, the resemblance to *Ctenoptychius pectinatus* is striking. In other places, particularly in one place (it requires close observation to detect it), the appearances are interpretable as those of a series of fan-shaped, ridged, and denticulated bodies, resembling the smaller forms of *Ctenoptychius pectinatus*. It is just here, however, in these crucial cases, where observation is most difficult. A little confirmatory evidence may be gleaned from the observations and figures of Giebel*, previously discussed. His *Styracodus acutus* † reminds one of *Ctenoptychius*, and is accompanied by a spine which appears to resemble that of *Tristychius*.

At Burgh Lee, where the Carboniferous beds have been searched for fossils perhaps more thoroughly than in any other locality in this district, *Tristychius* is one of the commonest spines, as *Ctenoptychius pectinatus* is one of the commonest fossils; yet, strange to say, the teeth (of which a good view has been obtained in the specimens that I have described) have never, so far as I know, been detected in that locality. I have obtained *Tristychius* spines and *Ctenoptychius pectinatus* associated in the fish-bed at Abden, near Kinghorn, Fife, but not the *undoubted* teeth of *Tristychius*. On the Wardie horizon, again, I have obtained the teeth and spines of *Tristychius*, but not a single detached undoubted *Ctenoptychius*. In the English Coal-measures *Ctenoptychius pectinatus* is common; but neither spines of *Tristychius* nor undoubted *Tristychius* teeth have been, so far as I know, discovered‡. It will thus be seen that the evidence from association or the lack of it is exceedingly conflicting and of dubious value, whether for the affirmative side or the negative.

On the whole, whilst believing that the two forms of teeth will be found to belong to the same fish, I do not yet consider it placed beyond question, and some reserve must be exercised before deducing much from it.

Summary.—The preceding descriptions indicate a shark of small size. The buccal opening seems to have been of considerable relative dimensions. The teeth were exceedingly numerous, and formed closely compacted regular (?) rows reaching back for a distance of probably from a half inch to an inch from the anterior extremity of the mouth. They ap-

* *Loc. cit.* † Reproduced Pl. VII. fig. 19.

‡ I should be glad to be corrected here if I am wrong, as I possibly am.

pear to have been of two kinds :—one prehensile, with well-developed median and lateral cusps ; the other without specially prominent elevations, and occupying a different position in the mouth. The skin was clothed with a dense armour of tubercles, the veritable shagreen of these ancient sharks. The horizontal fins (or some of them) were protected anteriorly by gracefully curved, ridged, grooved, and denticulated spines*. (The presence of dorsal spines, protecting fins or otherwise, is not proved.) There were at least four on every fish. They varied a good deal in different individuals, but were *identically similar* in the same fish. The peculiarly curved spines known as *sphenonchi* and found with *Hybodus* do not appear on this fish. The endoskeleton was cartilaginous. The axis was persistently notochordal and unsegmented, but gave off (neurally and hæmally) spines that were composed of granular cartilage, closely apposed, probably alternately arranged on opposite sides of the axis, and directed backwards, the whole conforming to the simplest and most ancient types of axial structure. These statements, or the majority of them, rest upon tolerably well-ascertained facts, and though far from sufficient to elucidate the whole structure of the fish, form at any rate a useful contribution to its history.

Affinities.—Certain characters of which much is properly made in the classification of recent Selachian fishes, such as the presence or absence of the *membrana nictitans*, the confluence of the nostrils with the mouth, the presence or absence of spiracles, and the notching of the pectoral fins at their origin, are of course practically inapplicable to most sharks in a fossil condition, notwithstanding the surprising perfection in which such remains (in post-Palæozoic rocks) have been obtained. Nor do I think that the important series of investigations now being carried on with so much zeal by Prof. Hasse† will be of much service to students of the Selachian remains of the older rocks‡.

There abides, however, a valuable set of characters by the use of which a natural classification will no doubt be gradually conquered. Important amongst these are the pinnation and dentition. Science owes a debt of gratitude to Messrs. Han-

* I have seen one or two spines considerably larger than the largest figured.

† Das natürliche Syst. d. Elasmobranchier.

‡ He arrives at a singular conclusion with regard to *Tristychius*. He says (*op. cit.* 1st part, p. 62), "Alle diese Formen (*Asteracanthus*, *Myriacanthus*, *Priscacanthus*, *Tristychius*) sind demnach meiner Ansicht nach jüngeren Holocephalen zuzurechnen, welche sich mit *Asteracanthus* bis in den mittleren Jura hineinerstreckten und von denen *Tristychius* in seiner Form sich am meisten an unsere jetzt lebende *Chimæra* anschloss."

cock and Atthey for breaking down the traditionary notion that all fossil spines were dorsal.

In a clever research* (based upon very scattered material) they showed that spines of *Gyracanthus*, till then believed to be dorsal, were really pectoral; and I have been able to confirm their conclusions† by the finding of an interesting specimen containing well-preserved remains of the pectoral arch. I consider that Messrs. Hancock and Atthey, by these observations, have opened up a very promising future for selachological inquiry; for whilst the soft structures of the fins will (except in the rarest cases) have left no trace of their existence, we may expect that the spines which protected them will frequently be preserved in their proper relations.

I have thus tried to hint at the lines upon which any real advance in our knowledge of the Palæozoic sharks will probably be made. I am unfortunately not able to utilize them to any great extent in the discussion of the affinities of *Tristychius*. By the spines it is allied to *Ctenacanthus* through *Tristychius minor*, Portlock.

The appendages of the cutis differ greatly from those found on *Hybodus*‡. They bear, however, a strong resemblance to those of *Ctenacanthus hybodoides*, Ag. (= *Cladodus mirabilis*, Ag.§), and *Gyracanthus tuberculatus*, Ag. Their value for purposes of classification, however, is probably slight, judging from recent genera.

The teeth of *Tristychius* are even more Hybodont in facies than the probably closely allied teeth which Giebel referred to *Hybodus* ‖.

The *Ctenoptychius pectinatus* tooth (if proved to belong to this genus) would detract a good deal from the (probably extreme) value which has been attributed to the amount of the lateral cuspidal elevation of the teeth, in defining species and genera commonly ascribed to the Hybodontidæ. It is extremely unfortunate that the evidence is no clearer either for or against this unexpected association.

After weighing the evidence now set forth, I incline to the belief that *Tristychius* was Hybodont, but not *Hybodus*, and should not be much surprised if the future proved that *Cladodus* (or a part of it) was a closer ally than *Hybodus*.

* *Loc. cit.*

† In a paper read to the Edinburgh Naturalists' Field Club, but not yet published.

‡ I have had few opportunities of studying *Hybodus*. Excellent undescribed Mesozoic material exists; and it is much to be desired that some one who has access to it would describe it.

§ Messrs. Hancock and Atthey have brought forward an amount of evidence which amounts to proof that the tooth of *Ctenacanthus hybodoides*, Ag., was *Cladodus mirabilis*, Ag. ‖ *Loc. cit.*

EXPLANATION OF PLATE VII.

Fig. 1. *Tristychius fimbriatus*, Stock, nat. size.
Fig. 1 *a*. The same, restored.
Figs. 2 & 2 *a*. *Styracodus acutus*, Giebel (= *Tristychius* ?).
Figs. 3 & 3 *a*. Referred by Giebel to *Hybodus* (= *Pleuracanthus* ?).
Figs. 4 & 4 *a*. *Chilodus gracilis*, Giebel (= *Diplodus* ?).
Figs. 5 & 5 *a*. *Hybodus vicinalis*, Giebel (= *Tristychius* ?).
Figs. 6 & 6 *a*. *Hybodus carbonarius*, Giebel (= *Tristychius* ?).
Figs. 7 & 7 *a*. *Tristychius arcuatus*, Ag., nat. size, and point enlarged.
Fig. 8. *Tristychius arcuatus*, Ag., nat. size. *s*, fragment of pectoral spine; *n*, displaced neural spines; *r*, doubtful traces of the rays of the pectoral fin.
Fig. 9. Tooth of *Tristychius arcuatus*, Ag., nat. size.
Fig. 10. The same, showing base, nat. size.
Fig. 11. The same, nat. size.
Fig. 12. Four teeth of *Tristychius arcuatus*, Ag., in natural position, nat. size.
Figs. 13 & 13 *a*. Spine of *Tristychius arcuatus*, Ag.: fig. 13 nat. size; fig. 13 *a* enlarged, to show the nature of the sculpture.
Figs. 14 & 14 *a*. Dermal tubercle of *Hybodus carbonarius*, Giebel; fig. 14 enlarged.
Fig. 15. Dermal tubercle of *Tristychius arcuatus*, Ag., much enlarged.
Fig. 15 *a*. The same, one of the prongs much enlarged, to show the sculpture.
Fig. 16. Dermal tubercle of *Ctenacanthus hybodoides*, Ag., slightly enlarged.
Fig. 17. Dermal tubercle of *Gyracanthus tuberculatus*, Ag., much enlarged.
Fig. 17 *a*. The same, one of the prongs much enlarged to show the diagonal sculpture.
Fig. 18. Tooth of *Tristychius arcuatus*, Ag., enlarged, showing the slight elevation of the lateral cusps.
Fig. 19. *Styracodus acutus*, Giebel.

BIBLIOGRAPHICAL NOTICES.

Atlas de la description physique de la République Argentine contenant des vues pittoresques et des figures d'Histoire naturelle composées par le Dr. H. Burmeister. Directeur du Musée public de Buenos Aires, &c. Le texte traduit en français avec le concours de E. Daireaux. Deuxième section. *Mammifères.* Première Livraison. *Die Bartenwale der argentinischen Küsten.*

Erläuterungen zur Fauna Argentina, enthaltend ausführliche Darstellungen neuer oder ungenügend bekannter Säugethiere von H. Burmeister, &c. Erste Lieferung. *Die Bartenwale der argentinischen Küsten.* Buenos Aires: Paul-Emile Coni. Paris: F. Savy. Halle: Ed. Anton. 1881.

Dr. Burmeister's 'Natural History of the Argentine Republic' was interrupted on the completion of the first section by a change of government. The author, however, had from time to time trans-